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Wiwa Creek Near Hodgeville Hydrology Study

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WIWA CREEK NEAR HODGEVILLE

HYDROLOGY STUDY

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October, 1981

SYNOPSIS

As part of the Canada-Saskatchewan Flood Damage Reduction (FDR) Program, a study of the potential flood flows in Wiwa Creek near Hodgeville has been carried out.

Streamflow data for Wiwa and nearby Notukeu Creeks, as well as for more distant hydrometric stations, were used to estimate annual runoff and peak flows for the 10, 25, 50, 100 and 500 year events. A typical or characteristic hydrograph for each flood of interest was developed.

CONTENTS

		Page
	SYNOPSIS	
I	INTRODUCTION	1
	A. GENERAL	1
	B. BASIN DESCRIPTION	1
II	BASIN RUNOFF POTENTIAL	3
	A. HYDROMETRIC DATA	3
	B. RUNOFF VOLUMES	4
	C. PEAK FLOWS	7
	D. FLOOD HYDROGRAPHS	10

TABLES

Table 1	POTENTIAL FLOOD VOLUME AND PEAK DAILY FLOW FOR WIWA CREEK NEAR HODGEVILLE	10

ILLUSTRATIONS

Figure 1 KEY MAP: WIWA CREEK BASIN UPSTREAM OF HIGHWAY NO. 58

Figure 2 WIWA CREEK NEAR HODGEVILLE ANNUAL RUNOFF VOLUME FREQUENCY CURVES BY VARIOUS METHODS ON GUMBEL PROBABILITY PAPER

Figure 3 WIWA CREEK NEAR HODGEVILLE ANNUAL RUNOFF VOLUME FREQUENCY CURVES BY VARIOUS METHODS ON LOG PROBABILITY PAPER

Figure 4 WIWA CREEK NEAR HODGEVILLE MAXIMUM DAILY DISCHARGE FREQUENCY CURVES BY DIFFERENT DISTRIBUTIONS ON GUMBEL PROBABILITY PAPER

Figure 5 WIWA CREEK NEAR HODGEVILLE MAXIMUM DAILY DISCHARGE FREQUENCY CURVES BY DIFFERENT DISTRIBUTIONS ON LOG PROBABILITY PAPER

Figure 6 WIWA CREEK NEAR HODGEVILLE FLOOD HYDROGRAPHS FOR THE 10, 25, 50, 100 AND 500 YEAR FLOOD EVENTS

I

INTRODUCTION

A. GENERAL

The Village of Hodgeville has, in the past, experienced flooding from nearby Wiwa Creek, and a flood hazard mapping program for the village was initiated by the Canada-Saskatchewan Flood Damage Reduction (FDR) Program Steering Committee. At the committee's request, the Hydrology Branch of Saskatchewan Environment conducted a study of the flood flow potential of Wiwa Creek near Hodgeville. Presented in this report are the results of the study, including hydrographs of 10, 25, 50, 100 and 500 year flood events.

B. BASIN DESCRIPTION

Wiwa is one of the main creeks tributary to the lower Wood River. Its drainage area, shown on Figure 1, has its most westerly limits in Range 12 southwest of Swift Current, and the creek follows an easterly course through more than seven townships to its confluence with the Wood River north of Gravelbourg.

Wiwa Creek basin has a generally well developed drainage pattern. This is particularly evident in the upper or western half of the basin, where there are many small tributaries, and drainage is off the hills lying both north and south of the main creek. Downstream of Hodgeville, which is near the mid point in its course, the creek starts to traverse a more mildly sloping area in which it is joined by only a few tributaries. However, Flowing Well Creek is a main tributary which drains a considerable area to the northwest, and

joins Wiwa Creek some distance downstream from Hodgeville. Total relief in the basin is over 725 feet or 220 metres. There is also a high ratio of effective to gross[1/] drainage area, which indicates that only a small portion of the basin does not contribute to streamflow in a normal runoff year.

1/ The "effective" drainage area is that area in the basin which might be expected to contribute runoff to the main stream in an average or normal runoff year.

The "gross" drainage area is the area which may contribute to streamflow under extremely wet conditions, but which also defines the boundary between two watersheds.

II

BASIN RUNOFF POTENTIAL

A. HYDROMETRIC DATA

Streamflow in Wiwa Creek has been measured intermittently, at several locations, for twenty of the last sixty or so years. For the former Water Survey of Canada (WSC) hydrometric station, Wiwa Creek near Gravelbourg, located near the Wood River confluence, records are available for the years 1921 through 1925, 1936, and continuously for the period 1966 through 1974. Continuous records are also available starting in 1975 for the present WSC station, Wiwa Creek near St. Boswells, located north of Bateman.

Some flow records are also available from provincial stations which were operated for a few years by the Saskatchewan Department of Agriculture. Spring flow in Wiwa Creek near Hodgeville was recorded for the years 1955 and 1965 through 1970, and in Wiwa Creek near St. Boswells for 1971, 1972 and 1974.

Notukeu Creek, whose drainage area borders that of the Wiwa Creek basin on the south over a considerable distance, is also a tributary of the lower Wood River. Notukeu Creek near Gravelbourg is a former WSC station with flow records for the years 1923 through 1925, 1936, 1940, and 1944 through 1974. The present station, Notukeu Creek near Vanguard, has records of flow for the years 1915 through 1922, 1940 and a continuous record starting in 1944. A well based correlation between the flows at these two stations was possible because of the relatively large number of years in which

there was an overlapping record. From this correlation, flows for Notukeu Creek near Gravelbourg were estimated for any missing years for which flows were recorded at the Vanguard station.

Included in the available data, and accepted for purposes of the study, was a set of reconstructed natural flow volumes for Wiwa Creek near Gravelbourg for the 56 year period 1917 through 1972, prepared by PFRA, Hydrology Division and tabulated in their Hydrology Report No. 69[2/]. This set of natural flows was extended to the end of 1979, using values estimated from recorded flows.

B. RUNOFF VOLUMES

Recorded flow volumes in Wiwa Creek in earlier years, such as the 1920's, were considered to be identical to natural runoff. However, by the 1940's, Water Rights' records show some small project use and, in 1952, the Braddock dam, located in the upper part of the basin, was completed. For the later period of record, starting in 1966, natural runoff volumes were calculated from recorded values by allowing for both small project use and net annual diversions into Braddock reservoir. A graphical correlation between natural flow volumes in Notukeu Creek near Gravelbourg and Wiwa Creek near Gravelbourg was developed based on the respective magnitude of these values for the years of

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2/ Report on Water Supply for the Proposed Willow Bunch Thermal Power Project, Hydrology Report No. 69, July, 1974. PFRA, Hydrology Division.

common record. From this relationship, natural runoff volumes for Wiwa Creek near Gravelbourg were estimated for all the missing years of record in the 59 year period 1921-79 inclusive.

Natural runoff volumes for Wiwa Creek near Gravelbourg for each year of the above-mentioned period were used to estimate the corresponding natural runoff in Wiwa Creek near Hodgeville, based on the relative magnitude of the respective drainge areas. The estimated annual natural runoff in the creek at Hodgeville was then reduced by an amount which allowed for upstream diversion, that is, small project use and net diversion into Braddock Reservoir. In this way, an estimate of runoff volume was obtained for Wiwa Creek near Hodgeville under present development, for each year of the 59 year study period. The year 1952 stands out as a very high runoff year in which the estimated runoff volume was more than twice the next highest annual volume during the study period. Unfortunately, no flow records are available for that year for any of the Wiwa Creek stations.

The estimated annual runoff volumes for Wiwa Creek near Hodgeville under present development during the study period, were tabulated, and a plotting position assigned to each value based on its relative magnitude. Figures in the tabulation for those years in which flows were recorded at Hodgeville, or at the WSC stations near Gravelbourg or St. Boswells[3/], were then plotted on both

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3/ Since these three stations are located downstream from the prime runoff producing area of the basin, a high proportion of the basin runoff will pass all three stations. Since they are also a relatively short distance apart along the creek, there will not be a large difference in flow from one station to another. For purposes of the study, therefore, figures of annual runoff in Wiwa Creek near Hodgeville, which were based on records of flow at either of the two downstream stations, were also treated as recorded flows.

Gumbel and Logarithmic probability paper. One additional point for the estimated 1952 runoff was plotted, because of its importance in bracketing the range of annual runoff during the study period. A frequency curve was drawn on Gumbel paper on the basis of the plotted points representing recorded flow, but giving recognition also to the magnitude of the estimated 1952 runoff. Similarly, on the Logarithmic paper, a best fit straight line was drawn through the plotted points exceeding a 1:2 magnitude, again recognizing that the 1952 runoff figure represented an estimated rather than a recorded flow.

The array of annual flood volumes was also analysed using the FDR Program analysis[4/] for the following frequency distributions: Gumbel 1, Log Normal, Three Parameter Log Normal, and Log Pearson Type III fitted by maximum likelihood and by the method of moments. In these mathematical solutions all values in the array are assumed equal and it is not possible to give more weight to recorded values as opposed to estimated flows.

There was a relatively wide range of difference in the results of the analysis for floods larger than 1:10, using different distributions and graphical as well as mathematical solutions. The various curves are shown plotted together on each of Gumbel and Log

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4/ Engineering Hydrology Section, Engineering Division, Water Planning and Management Branch, Inland Waters Directorate, Environment Canada, "Flood Damage Reduction Program Flood Frequency Analysis", R. Condie, G. A. Nix and L. G. Boone, Ottawa, Ontario, June, 1976.

probability paper, on Figures 2 and 3 respectively. This provides a graphical comparison between the various curves, showing also the degree of fit between the mathematically derived curves and the plotted points, which represent annual runoff volumes. As shown in these figures, the mathematically derived Log Normal and Three Parameter Log Normal curves would tend to give extremely high values, and the Gumbel 1 curve extremely low values for the larger floods, in relation to the plotted points.

A best estimate frequency curve for the study, selected on the basis outlined above, was the manually drawn Gumbel curve No. 6, shown along with the other curves on Figures 2 and 3. The mathematically derived curve, Log Pearson III by maximum likelihood, would have given slightly higher values for 1:50 and larger floods. However, it was felt that such higher estimates could not be justified on the basis of one high runoff year which, in addition to being an estimated value, appeared as an outlier among the plotted points.

C. PEAK FLOWS

There are many common years of flow record for the two Notukeu Creek hydrometric stations, one near Vanguard and the other near Gravelbourg, and also for these two stations and Wiwa Creek near Gravelbourg in the adjacent basin. For the two Notukeu Creek stations a logarithmic correlation, based on the years of common record, was used to extend the peak flow record by a few years back to 1915 for Notukeu Creek near Gravelbourg. For both stations

however, the period 1926 through 1943 consists almost entirely of missing data years.

Three station records were used to estimate, by means of logarithmic correlation, daily peak flows in Wiwa Creek near Gravelbourg for missing years in the 65 year period 1915-79 inclusive. Records of Notukeu Creek near Gravelbourg were used to estimate peaks for the years 1915-20, 1940, 1944-65 and 1975-79 inclusive, with a correlation coefficient of 0.885 and standard error of 0.34 log units. Records for East Poplar River at the International Boundary were used to estimate peaks for the years 1931-35, 1937-39 and 1941-43 inclusive, with a correlation coefficient of 0.799 and standard error of 0.51 log units. McEachern Creek at the International Boundary records were used to estimate peaks for the years 1926-30 inclusive, with a correlation coefficient of 0.748 and a standard error of 0.52 log units.

As previously noted, there is a limited record of spring runoff for Wiwa Creek near Hodgeville, consisting of six years in which a significant runoff was monitored. Peak flow from this record showed a fairly consistent relationship with the corresponding peaks recorded downstream in Wiwa Creek near Gravelbourg. Given that the two stations are located a relatively short distance apart on the same stream, and in the absence of more data, this indication of a consistent relationship was accepted for purposes of the study, and used to estimate peak flows at Hodgeville for the remaining years of the peak flow study period.

Peak daily flows for the 65 year period were tabulated, and a plotting position assigned to each based on its relative magnitude. Included in the plotted points was the highest peak in the array, which was estimated from outside the basin, but otherwise the plotted points represented only years in which flows had actually been recorded in Wiwa Creek. Frequency curves were drawn on the basis of the plotted points on each of Gumbel and Logarithmic probability paper.

The flood peak array was also analysed mathematically by use of the FDR Program which gives results for various distributions provided in the program. As in the flood volume analysis, there was a wide range of difference in these calculated results. For example, the mathematically derived Gumbel 1 resulted in an estimate of the 500 year flood peak which was only slightly above the highest constructed peak for the 65 years. At the other extreme, the mathematically derived log normal distribution gave an estimate of the 500 year flood peak which was almost five times the highest constructed peak. Curves were drawn for each of the various mathematical solutions, along with the two manually derived curves, on each of Gumbel and Log probability paper on which the points representing individual peak flows had been plotted. This graphical representation of the various curves and the plotted points are shown on Figures 4 and 5 on Gumbel and Log probability paper, respectively. Using this comparison, it was concluded that the manually drawn Gumbel curve does in fact best fit the plotted points, and values from that curve were accepted as the "best estimate" values for purposes of the study.

Table 1 summarizes the results of the flood frequency analysis for Wiwa Creek near Hodgeville, for floods ranging from the 1:2[1/] to the 1:500 runoff event.

D. FLOOD HYDROGRAPHS

Shaping of theoretical flood hydrographs for Wiwa Creek near Hodgeville was based on flow records for the creek at that location. Partial or complete hydrographs on record for five years, 1965, 1966, 1967, 1969 and 1970, were plotted on semi-log paper. A best fit straight line was drawn which would be representative or characteristic of the slope of each of the rising and recession limbs of the plotted hydrographs. This procedure resulted in a characteristic slope for the rising limb of 2½ days per log cycle, and for the recession limb of 7 days

TABLE 1

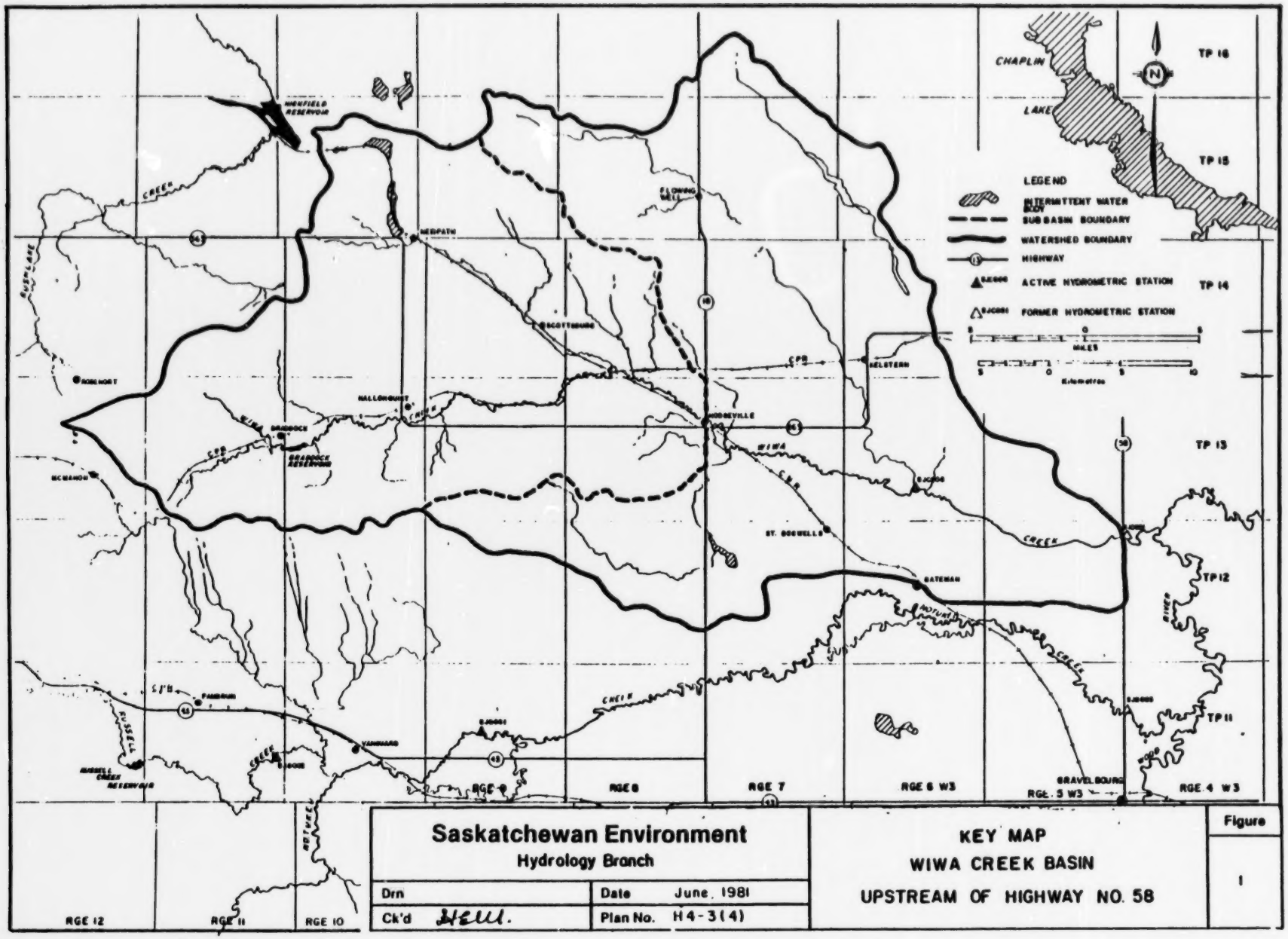
POTENTIAL FLOOD VOLUME AND PEAK DAILY FLOW
FOR WIWA CREEK NEAR HODGEVILLE

Probability in any one Year is:	That the Mean Daily Peak Flow will Equal or Exceed:		That the Annual Runoff Volume will Equal or Exceed:	
	cfs	m^3/s	Acre-Feet	dam^3
1:2	400	11.5	2000	2470
1:10	1200	34	12800	15800
1:25	1700	48	19500	24000
1:50	2100	60	25000	31000
1:100	2550	72	31000	38000
1:500	3600	102	44000	54000

[1/] Although not requested by the FDR Steering Committee, values for the 1:2 runoff magnitude were estimated in the course of the study. By including these figures in Table 1 a more complete range of runoff events is indicated.

per log cycle down to 100 cfs or 3 m^3/s, and 17 days per log cycle below this flow value. These typical slopes where then used, along with peak flow and volume[5/] already estimated, to construct the required daily flow hydrographs, shown on Figure 6, for the 10, 25, 50, 100 and 500 year flood events in Wiwa Creek near Hodgeville.

5/ It was assumed in constructing theoretical hydrographs that there is a direct relationship between a given magnitude of runoff volume and flood peak, in which for example a 1:25 flood event will feature that magnitude of both runoff volume and peak flow. This is considered valid for the purpose of the study, but has limitations when applied to some individual years in which, for example, a 1:10 flood volume could occur along with a 1:25 peak flow, while in another year these particular magnitudes of volume and peak could be reversed.



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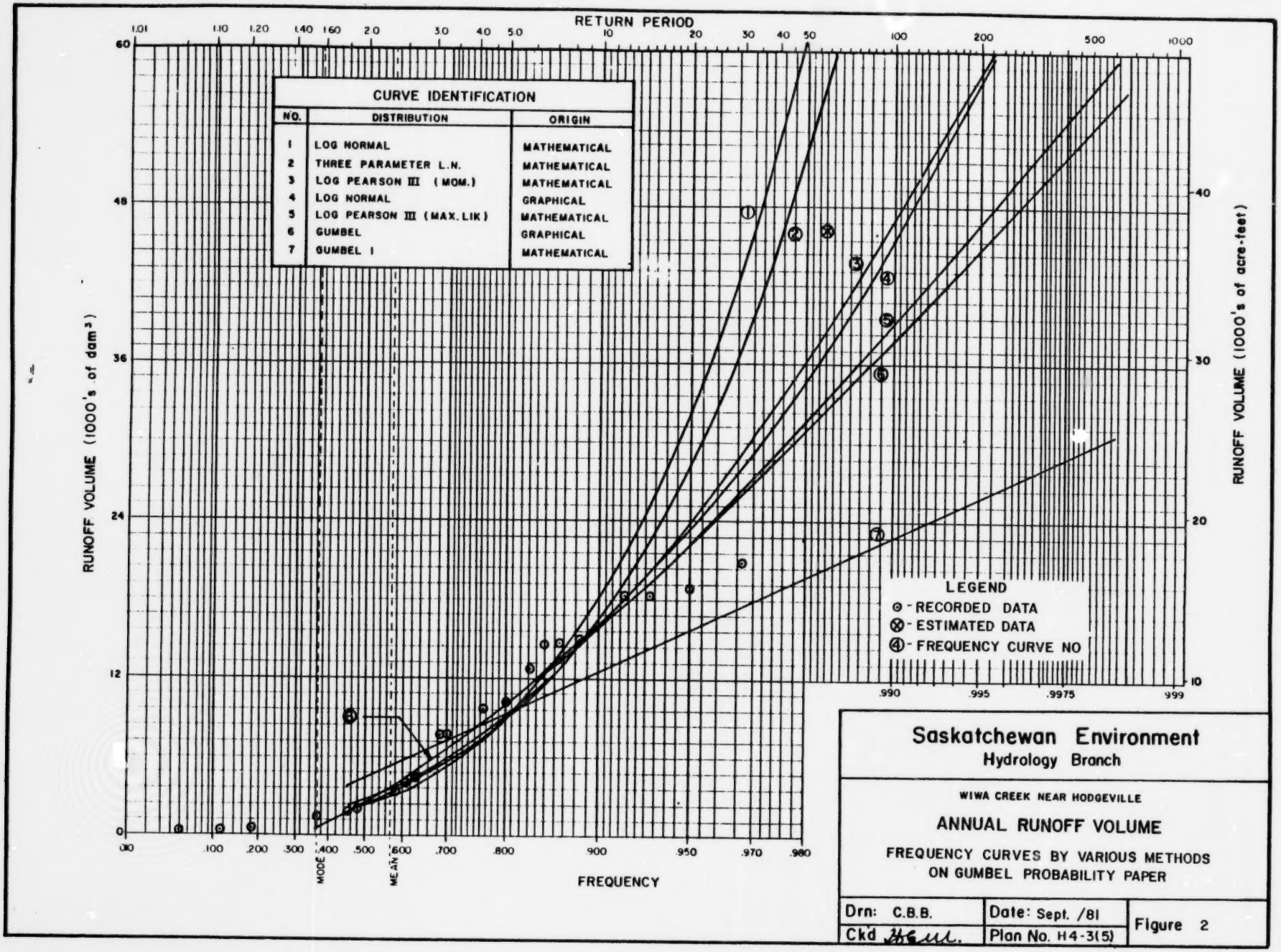
Drn		Date	June, 1981
Ck'd	Hell.	Plan No.	H4-3(4)

KEY MAP
WIWA CREEK BASIN
UPSTREAM OF HIGHWAY NO. 58

Figure 1



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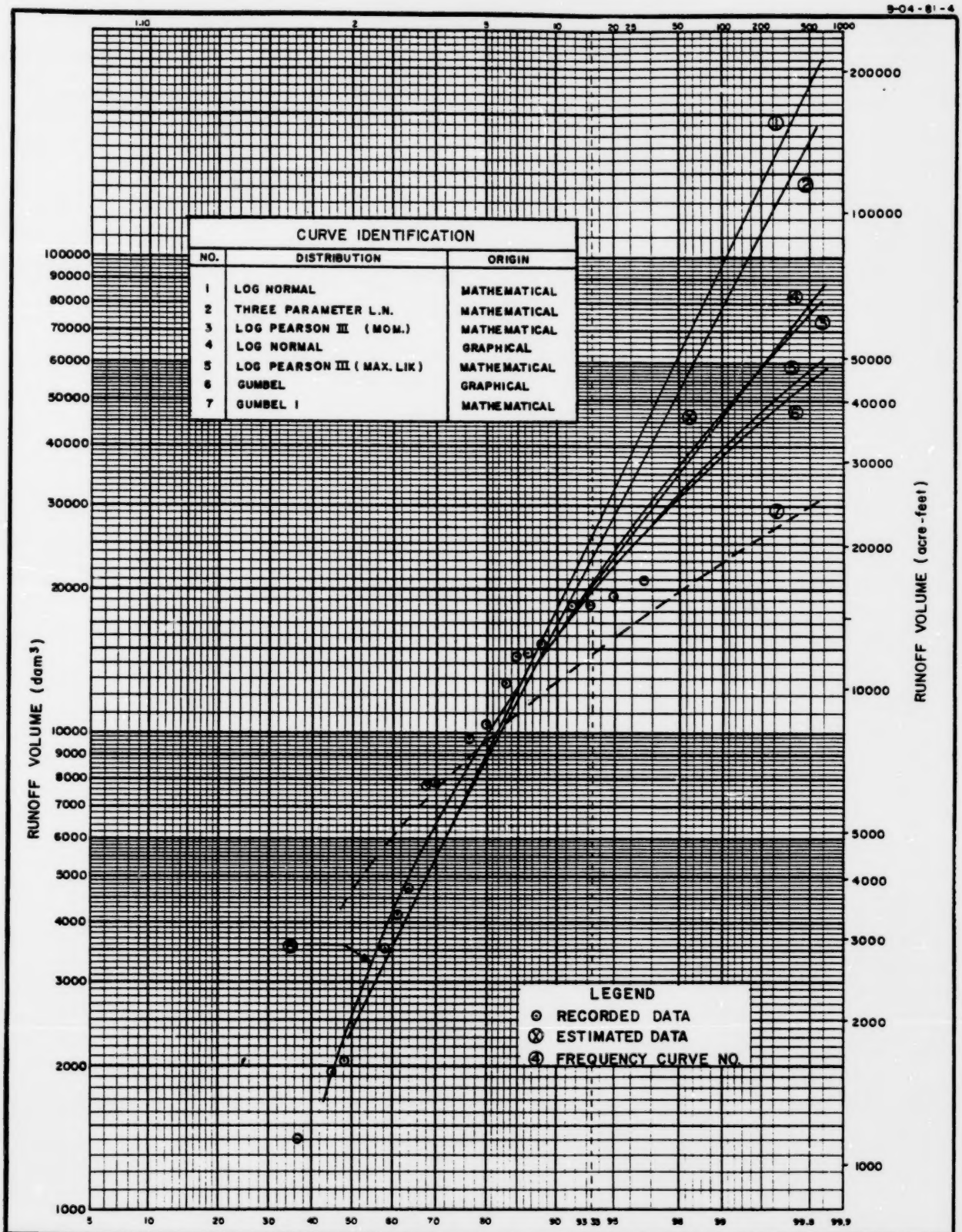
WIWA CREEK NEAR HODGEVILLE

ANNUAL RUNOFF VOLUME

FREQUENCY CURVES BY VARIOUS METHODS
ON GUMBEL PROBABILITY PAPER

Drn: C.B.B.	Date: Sept. /81	Figure 2
Ckd [illegible]	Plan No. H4-3(5)	



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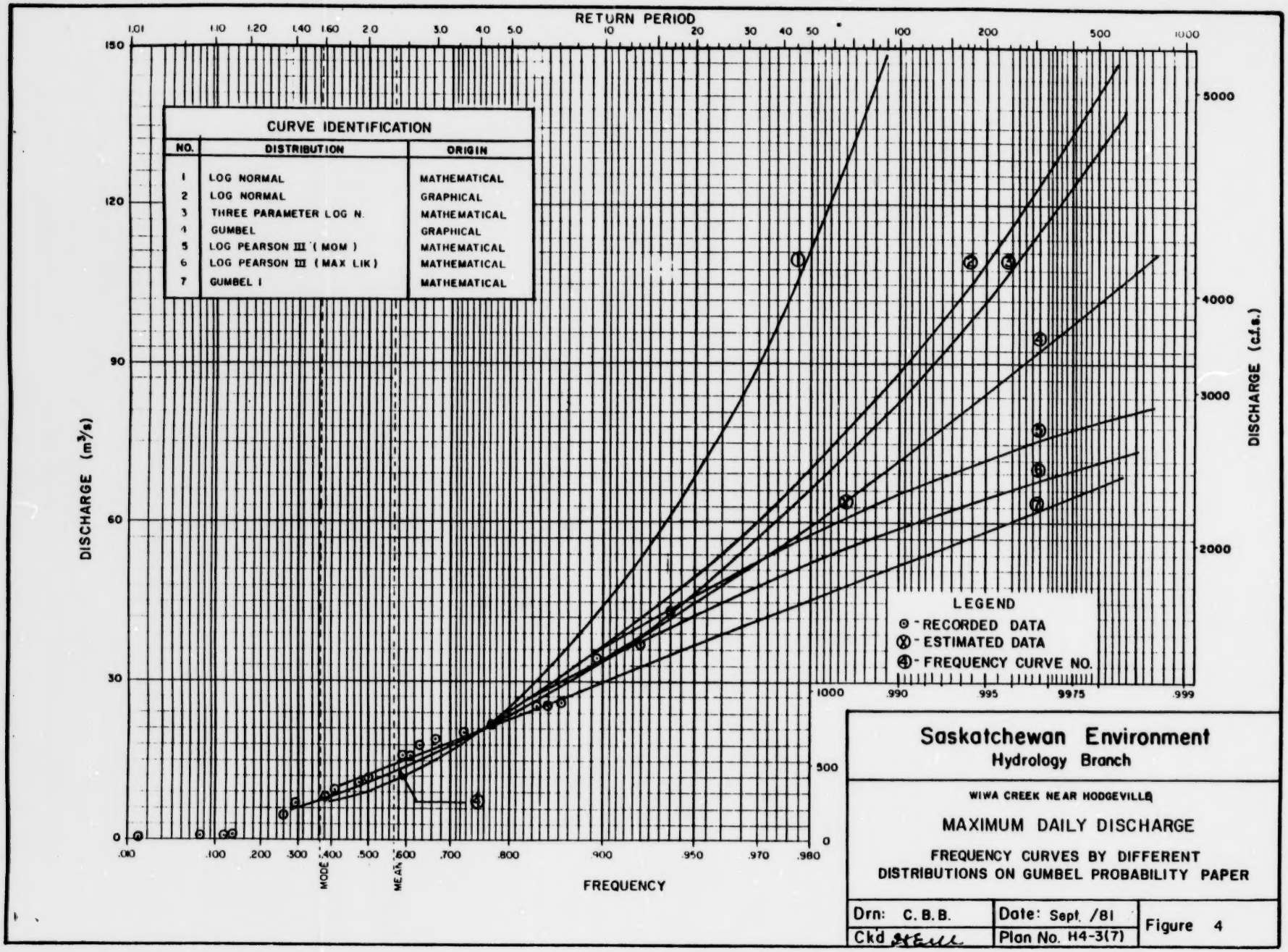
Drn. C. B. B.	Date: Sept. /81
Ck'd.	Plan No. H4-3(6)

WIWA CREEK NEAR HODGEVILLE

ANNUAL RUNOFF VOLUME

FREQUENCY CURVES BY VARIOUS METHODS ON LOG PROBABILITY PAPER

Figure 3



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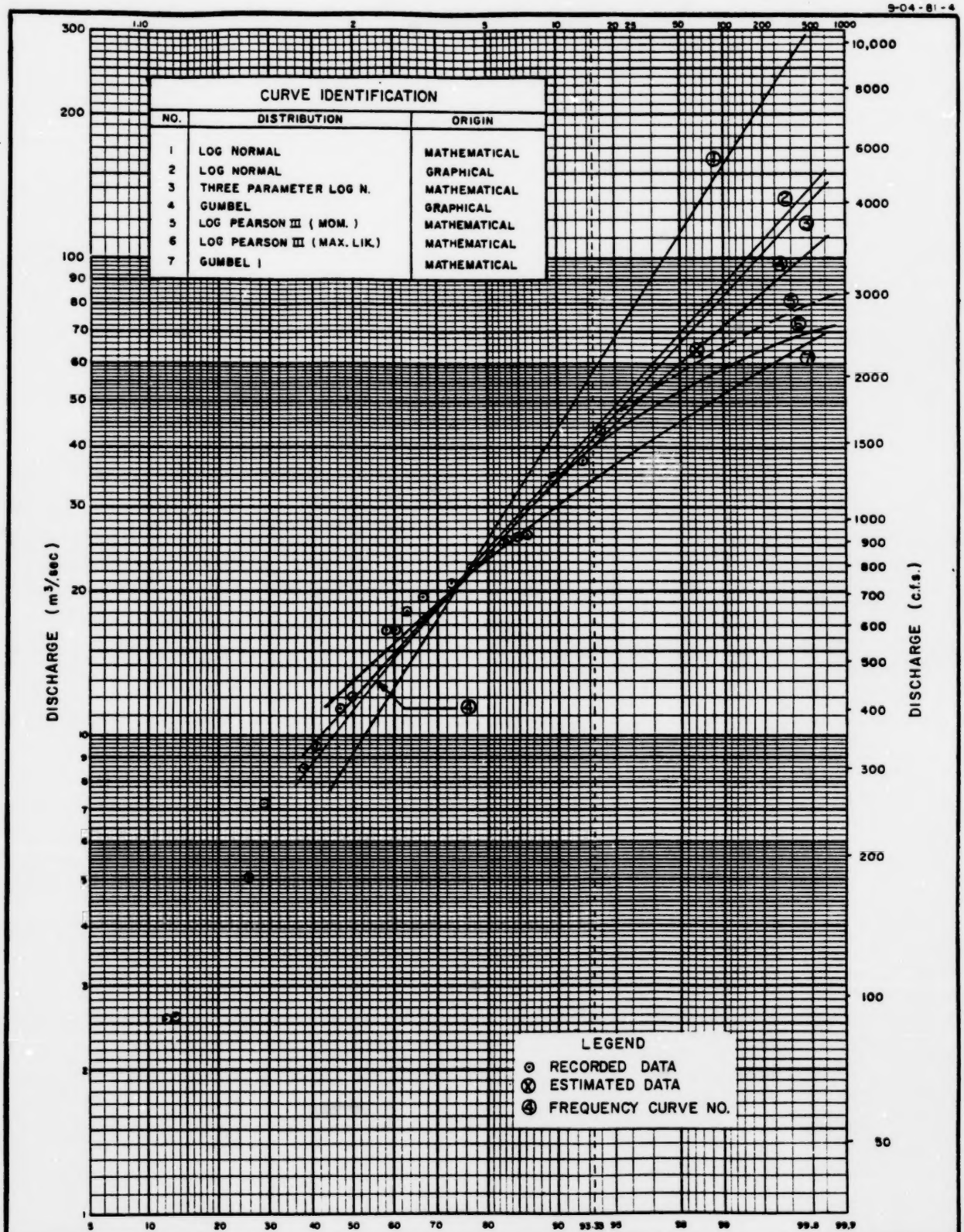
WIWA CREEK NEAR HODGEVILLE

MAXIMUM DAILY DISCHARGE

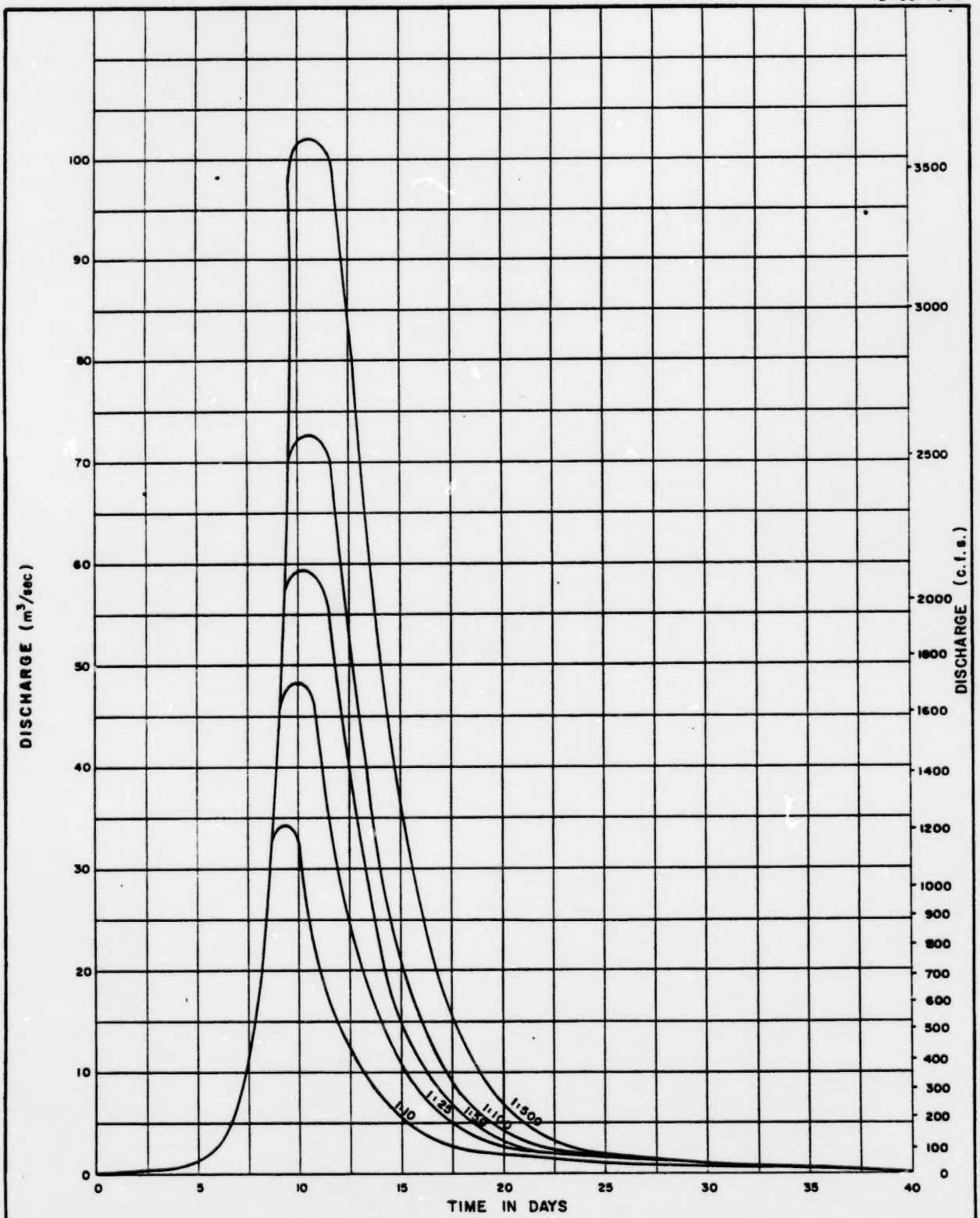
FREQUENCY CURVES BY DIFFERENT DISTRIBUTIONS ON GUMBEL PROBABILITY PAPER

Drn: C.B.B.	Date: Sept. /81	Figure 4
Ckd	Plan No. H4-3(7)	


CURVE IDENTIFICATION
NO. | DISTRIBUTION | ORIGIN
1 | LOG NORMAL | MATHEMATICAL
2 | LOG NORMAL | GRAPHICAL
3 | THREE PARAMETER LOG N. | MATHEMATICAL
4 | GUMBEL | GRAPHICAL
5 | LOG PEARSON III (MOM.) | MATHEMATICAL
6 | LOG PEARSON III (MAX. LIK.) | MATHEMATICAL
7 | GUMBEL I | MATHEMATICAL
LEGEND
RECORDED DATA
ESTIMATED DATA
FREQUENCY CURVE NO.
DISCHARGE (m³/sec)
DISCHARGE (c.f.s.)

Saskatchewan Environment Hydrology Branch	WIWA CREEK NEAR HODGEVILLE MAXIMUM DAILY DISCHARGE FREQUENCY CURVES BY DIFFERENT DISTRIBUTIONS ON LOG PROBABILITY PAPER	Figure 5
Drn. C.B.B. Date: Sept. /81 Ck'd. Plan No. H4-3(8)		

B-09-79-4



Saskatchewan Environment Hydrology Branch		WIWA CREEK NEAR HODGEVILLE FLOOD HYDROGRAPHS FOR THE 10, 25, 50, 100 AND 500 YEAR FLOOD EVENTS	Figure 6
Drn.: C.B.B.	Date: Sept. /81		
Ck'd.:	Plan No. H4-3(9)		